aged frame. Let us say, too, that happy is the private citizen, or the time-worn statesman, who passes away to his rest, and to his reward, as did JOHN ADAMS, with the united acclaim of friend and foe, that he was a man of "unconquerable intrepidity, and of incorruptible integrity." As yet, the extent and the value of the services which he rendered to the Anglo-Saxon race are not generally understood or appreciated. The means of better information are afforded by these volumes; and most earnestly do we commend them to the study of the young men of our country, who, soon to come upon the theatre of affairs, will seek some guide, and who may safely form their characters, public and private, upon a model which had neither a vice nor a crime to tarnish a long, varied, and unprecedentedly arduous career.

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ART. II. — 1. *Human Physiology, Statical and Dynamical; or the Conditions and Course of the Life of Man.* By JOHN WILLIAM DRAPER, M. D., LL. D., Professor of Chemistry and Physiology in the University of New York. New York: Harper and Brothers. 1856. 8vo. pp. 649.

2. *The Mutual Relations of the Vital and Physical Forces.* By WILLIAM B. CARPENTER, M. D., Examiner in Physiology and Comparative Anatomy in the University of London. From the "Philosophical Transactions," Part II., for 1850. London. 1850. 4to. pp. 37.

3. *The Correlation of Physical Forces.* By W. R. GROVE, M. A., F. R. S., Barrister-at-Law. Second Edition. London. 1850. 8vo. pp. 119.

4. *Caloric; its Mechanical, Chemical, and Vital Agencies in the Phenomena of Nature.* By SAMUEL L. METCALFE, M. D., of Transylvania University. London. 1843. 2 vols. 8vo. pp. 1100.

THE appearance of Professor Draper's ingenious and original treatise on Physiology must call the attention of a large class of readers to those higher questions of the science which

are freely discussed in its pages. The scientific and literary character of the work has been made the subject of special notice in various other quarters. It is agreed that Professor Draper has given us a book that is full of interest, containing many striking views and novel experimental illustrations. Its faults spring out of its merits, and are such as belong to most works of science written by men of lively imagination. We make our sincere acknowledgments to the author for the fresh contributions he has furnished to our knowledge of the laws of life, and the new impulse he has imparted to the study of its mysteries.

We have prefixed to this paper the titles of two essays, published within the last few years, and also of a ponderous volume which saw the light before either of them, and has been, or seems to have been, less read than either. Mr. Grove's essay has excited great attention in England, and received the honors of translation into the French language. Dr. Carpenter's paper, published in the "Philosophical Transactions," extended the generalizations of Mr. Grove into the domain of Physiology. Both are brief, and are therefore read. Dr. Metcalfe forgot the motto which he must have often seen quoted from D'Alembert: "The author kills himself in spinning out what the reader kills himself in cutting short." Consequently his book has been shelved, in spite of its originality and learning. But we must do our countryman the justice to say, that, if there is anything in the physical theory of vital actions which has found advocates in Mr. Newport and Dr. Carpenter, and which Professor Draper has so forcibly illustrated, Dr. Metcalfe has anticipated them all in maintaining that caloric "is alone, of every form of being, quick or dead, the active principle"; the same doctrine, modernized, which, in another form, was taught by Hippocrates. And we must be permitted to express our astonishment that a work of such pretensions, published in London, should be ignored by any English writer of authority, while he is repeating and developing its leading ideas, long since given to the world.

We do not propose to make a critical examination of any of these publications. We only avail ourselves of them for the purpose of opening one of the questions which all of them

suggest or discuss. This is the relation existing between the physical agencies of general nature and the peculiar manifestations of living beings. The interest of physiologists was especially called to this subject by the well-known Lectures of Professor Matteucci, delivered in the University of Pisa, by appointment of the Tuscan government, in 1844. A translation of these Lectures was introduced to the English public under the auspices of Dr. Pereira and Professor Faraday. From that time, the questions involved in the comparison of living and lifeless nature have attracted more and more attention, until they have become, in a measure, blended with popular studies. We propose to select one subdivision of this vast subject for such discussion as may not be unfitted for the eye of the unprofessional student of nature.

If the reader of this paper live another complete year, his self-conscious principle will have migrated from its present tenement to another, the raw materials, even, of which are not as yet put together. A portion of that body of his which is to be, will ripen in the corn of the next harvest. Another portion of his future person he will purchase, or others will purchase for him, headed up in the form of certain barrels of potatoes. A third fraction is yet to be gathered in a Southern rice-field. The limbs with which he is then to walk will be clad with flesh borrowed from the tenants of many stalls and pastures, now unconscious of their doom. The very organs of speech with which he is to talk so wisely, or plead so eloquently, or preach so effectively, must first serve his humbler brethren to bleat, to bellow, and for all the varied utterances of bristled or feathered barn-yard life. His bones themselves are, to a great extent, *in posse*, and not *in esse*. A bag of phosphate of lime which he has ordered from Professor Mapes, for his grounds, contains a large part of what is to be his next year's skeleton. And, more than all this, as by far the greater part of his body is nothing, after all, but water, the main substance of his scattered members is to be looked for in the reservoir, in the running streams, at the bottom of the well, in the clouds that float over his head, or diffused among them all.

For a certain period, then, the permanent human being is to

use the temporary fabric made up of these shifting materials. So long as they are held together in human shape, they manifest certain properties which fit them for the use of a self-conscious and self-determining existence. But it is as absurd to suppose any identification of this existence with the materials which it puts on and off, as to suppose the hand identified with the glove it wears, or the sponge with the various fluids which may in succession fill its pores. Our individual being is in no sense approximated to a potato by living on that esculent for a few months; and if we study the potato while it forms a part of our bodies under the name of brain or muscle, we shall learn no more of the true nature of our self-determining consciousness than if we studied the same tuber in the hill where it grew.

These forms of nutritive matter that pass through our systems in a continual round may be observed, weighed, tested, analyzed, tortured in a thousand ways, without our touching for a moment the higher problem of our human existence. Sooner or later, according to the perfection of our methods and instruments, we bring hard up against a deaf, dumb, blind fact. The microscope reaches a granule, and there it stops. Chemistry finds a few bodies which it cannot decompose, and plays with them as with so many dominos, counting and matching equivalents as our old friends of the Café Procope used to count and match the spots on their humbler playthings. But why $C_4$, $O_2$, $H_6$, have such a tendency to come together, and why, when they have come together, a fluid ounce of the resulting compound will make the small philosopher as great as a king for an hour or two, and give him the usual headache which crowns entail upon their wearers, the next morning, is not written in the pages of Lehmann, nor treasured in the archives of Poggendorf. Experimental physiology teaches how to stop the wheels of the living machinery, and sometimes how to start them when their action is checked; but no observation from the outside ever did or ever will approach the mystery of that most intense of all realities, — our relations, as responsible agents, to right and wrong. It will never answer, by aid of microscope, or balance, or scalpel, that ever-recurring question, —

" Whence this pleasing hope, this fond desire,
This longing after immortality ? "

The study of physical and physiological phenomena has been thought to lead to what is called materialism, or something worse. In spite of Galen's half-Christian religious eloquence, — in spite of Haller's defence of the faith, and of Boerhaave's apostolic piety, — we cannot forget the old saying, that where there are three physicians there are two atheists. It would be almost as fair to say, that where there are three bank-clerks there are two rogues. Unquestionably, the handling of large sums of money betrays into dishonesty some men who would have resisted slighter temptations. So the exclusive study of the bodily functions may, now and then, lead away a weak mind from the contemplation of the spiritual side of nature. The mind, like the eye, has its adjustment to near and remote objects. A watchmaker can find the broken tooth in a ship's chronometer quicker than the captain, and the captain will detect a sail in the distance long before the artisan can see it. Physiologists and metaphysicians look at the same objects with different focal adjustments; but if they deny the truths out of their own immediate range, their eyes have got the better of their judgment. If the mariner will not trust his chronometer to the expert, he loses his reckoning; if the nice-fingered myope should play sailor, the pirate would be sure to catch him. Our old, foolish proverb is not, therefore, wholly without its meaning. Charlatans in physiology, who are not so likely to be found in any other profession as in the one mentioned, make the mistake of confounding the results derived from their observation of the working of certain instruments, in health or disease, with those that claim another and a more exalted source. Our convictions, even without special divine illumination, reveal us to ourselves, not as machines, but as sub-creative centres of intelligence and power. The two ranges of mental vision should never be confounded for good or for bad. The laws of the organism cannot be projected, *a priori*, on the strength of the profoundest intuitions. Hunter's maxim, " Don't think, but try," comes down like a pile-driver on the audacious head possessed by the delusion that it can find out how things are,

by abstract speculation upon the question how they ought to be. But, on the other hand, the doctrine of an immortal spirit will never come from the dissecting-room or the laboratory, unless it is first carried thither from a higher sphere. Yet there is nothing in these workshops that can efface it, any more than their gases and exhalations can blot out the stars of heaven.

Thus what we have to say must be considered as applying solely to the living body, and not to the divine emanation which, in the human form, seems, but only seems, to identify itself for a while with the shape it uses. We shall not even think it necessary to consider the living body in all its attributes. Animals have a life in common with plants: they grow, they keep their condition, they decay; they reproduce their kind, they perish; and these acts, apart from self-consciousness or any voluntary agency, constitute them living creatures. This simplest and broadest aspect of living nature is that which we propose to consider.

Life may be contemplated either as a condition, manifested by a group of phenomena, or as the cause of that condition. Looked at as a condition, it is the active state peculiar to an organism, vegetable or animal, which consists in the maintenance of structural integrity by a constant interchange of elements with surrounding matter. This interchange is effected under the influence of certain exciting agencies, or stimuli, such as light and heat, which are essential to its due performance. An egg or a seed perishing undeveloped has never been excited into this active state, and therefore cannot be said to have lived. It was only for a time capable of living, if the proper stimuli and surrounding matters had been present.

But life may be considered, again, as a *cause* of the phenomena just referred to, and it is in this aspect that we mean to regard it; and before attempting to examine our special question, we must remember the limits of all our inquiries with reference to causation. We can hope for nothing more, in the way of positive increase of knowledge, than these results, in any such inquiry: — to detect the constant antecedents of any condition or change; to resolve one or more

antecedents into consequents of some previous fact; to show that one or more of the causative elements are the same that are productive of other effects; and, lastly, to reproduce the effect by supplying the causative conditions, or to prove the nature of the constant antecedent by experiment. As to the essence of causation or of force, in any of its aspects, we are no wiser than Newton, the profoundest student of its laws, and the readiest to confess his ignorance of its intimate nature.

Let us look first at the theological relations of an inquiry into the causes and nature of life. These, if nothing else, may, we think, be satisfactorily adjusted.

Every action, or series of actions, is referred by the mind to a force, and this again to a power. Thus the action of a clock is referred to the force of the spring, and this force is the manifestation of a power stored in the spring by winding it up, and set free by giving the first swing to the pendulum. We may consider action as the specific application of force; force, as the transfer of power, or power *in transitu;* power itself, as the original or delegated source of being, or of change in its condition. Thus life, which appears as a series of actions, is referred to a force commonly called vital, and this to a power, having its centre in the Divine Being; for all who recognize a Divinity are agreed that all power comes from him. This is what they mean when they call omnipotence one of his attributes. The first manifestations of force are habitually referred to the same original source. Thus we say that the Creator gave motion to the planets in space, taking it for granted that the Master-hand alone could impart their original impulse. If, however, we are asked why they continue to roll on, we are told that the *vis inertiæ* keeps them from stopping. But this is a mere name, and we might as well say that the *vis motus* starts a planet, as that the *vis inertiæ* keeps it going. A simpler statement is that the Divine agency, once in operation, never changes without cause. We cannot allow force to be self-sustaining any more than self-originating, nor matter itself to be self-subsistent any more than self-creating. "Actualia dependent a Deo tum in existendo, tum in agendo." "Neque male docetur conserva-

tionem divinam esse continuatam creationem, ut radius continue a sole prodit." Such are the words of Leibnitz. The apparent uniformity of force, and the seeming independent existence of matter, lead us to speak of them as if their laws, as we term them, were absolutely and eternally inherent. But a law which an omnipotent, omniscient, omnipresent Being enforces, is plainly nothing more than the Lawgiver himself at work. This is the meaning of that somewhat startling utterance of Oken, "The universe is God rotating." Transcendental Physiology is beginning to steal from the hymn-books.

> "With glory clad, with strength arrayed,
> The Lord, that o'er all nature reigns,
> The world's foundations strongly laid,
> And the vast fabric still sustains."

So sang Tate and Brady, paraphrasing the royal David. And Watts, still more expressly, in the hymn made famous by "the harp of thousand strings": —

> "His Spirit moves our heaving lungs,
> Or they would breathe no more."

Once giving in our complete adhesion to the doctrine of the "immanent Deity," we get rid of many difficulties in the way of speculative inquiry into the nature and origin of things. This may be an important preliminary. Mr. Newport, the very distinguished physiological anatomist, communicated a paper to the Linnæan Society, in the year 1845, "On the Natural History of the Oil Beetle, Meloë." It contained the following sentence: "The facts I have now detailed lead me, in conformity with the discovery by Faraday of the analogy of light with heat, magnetism, and electricity, to regard light as the primary source of all vital and instinctive power, the degrees and variations of which may, perhaps, be referred to modifications of this influence on the special organization of each animal body." The Council of the Society objected to the publication of the passage from which this is extracted. The Society's Index Expurgatorius would have been more complete, if it had included the Invocation of the third book of Paradise Lost, which has hitherto escaped the Anglican censorship.

But if the student of nature and the student of divinity can once agree that all the forces of the universe, as well as all its power, are immediately dependent upon its Creator, — that He is not only omni*potent*, but omni*movent*, — we have no longer any fear of nebular theories, or doctrines of equivocal generation, or of progressive development. If we saw a new planet actually formed in the field of the telescope, or the imaginary "Acarus Crossii" put together "de toutes pièces" under the microscope, true to its alleged pedigree, — out of Silex, by Galvanism, — it would no more turn us into atheists, than a sight of the mint would make us doubt the national credit.

We are ready, therefore, to examine the mystery of life with the same freedom that we should carry into the examination of any other problem; for it is only a question of what mechanism is employed in its evolution and sustenance.

We begin, then, by examining the general rules which the Creator seems to have prescribed to his own operations. We ask, in the first place, whether he is wont, so far as we know, to employ a great multitude of materials, patterns, and forces, or whether he has seen fit to accomplish many different ends by the employment of a few of these only.

In all our studies of external nature, the tendency of increasing knowledge has uniformly been to show that the rules of creation are simplicity of material, economy of inventive effort, and thrift in the expenditure of force. All the endless forms in which matter presents itself to us are resolved by chemistry into some threescore supposed simple substances, some of these, perhaps, being only modifications of the same element. The shapes of beasts and birds, of reptiles and fishes, vary in every conceivable degree; yet a single vertebra is the pattern and representation of the frame-work of them all, from eels to elephants. The identity reaches still further, — across a mighty gulf of being, — but bridges it over with a line of logic as straight as a sunbeam, and as indestructible as the scymitar-edge that spanned the chasm in the fable of the Indian Hades. Strange as it may sound, the tail which the serpent trails after him in the dust, and the head of Plato, were struck in the die of the same primitive conception, and

differ only in their special adaptation to particular ends. Again, the study of the movements of the universe has led us from their complex phenomena to the few simple forces from which they flow. The falling apple and the rolling planet are shown to obey the same tendency. The stick of sealing-wax that draws a feather to it, is animated by the same impulse that convulses the stormy heavens.

These generalizations have simplified our view of the grandest material operations, yet we do not feel that creative power and wisdom have been shorn of any single ray by the demonstrations of Newton or of Franklin. On the contrary, the larger the collection of seemingly heterogeneous facts we can bring under the rule of a single formula, the nearer we feel that we have reached towards the source of knowledge, and the more perfectly we trace that little arc of the immeasurable circle which comes within the range of our hasty observations, at first like the broken fragments of a many-sided polygon, but at last as a simple curve that encloses all we know or can know of Nature. To our own intellectual wealth, the gain is like that of the over-burdened traveller, who should exchange hundred-weights of iron for ounces of gold. Evanescent, formless, unstable, impalpable, a fog of uncondensed experiences hovers over our consciousness like an atmosphere of uncombined gases. One spark of genius shoots through it, and its elements rush together and glitter before us in a single translucent drop. It would hardly be extravagant to call Science the art of packing knowledge.

We are moving in the right direction, therefore, when we summon all the agencies of nature before the tribunal of Science, and try the question of their identity under their various *aliases*, just so often as a new set of masks or disguises is detected in their possession. The accumulated discoveries of late years have resulted in such a trial. Following the same course that Newton and Franklin followed in their generalizations, living philosophers have attempted to show relations of mutual convertibility, if not of identity, between the series of forces known as light, heat, electricity, magnetism, and chemical affinity. Some leading facts indicating their intimate relationship may be very briefly recalled.

A body heated to a certain point becomes luminous; its heat seems to pass over partly into the condition of light. Thus iron becomes *red*-hot at about 1,000° Fahrenheit. Light may, perhaps, be changed into, or manifest itself as heat. In Franklin's famous experiment, the black cloth, which absorbs all the luminous rays, sinks deepest into the snow. Light, again, may act chemically, as heat does, as we see in the results of photography. It may be fixed in a body, like heat, as is shown in the Bologna phosphorus, which shines for some minutes after being exposed to sunlight, or to the common light of day. Heat develops electricity, as in the various thermo-electric combinations of different metals. Electricity produces light, and sets fire to combustibles. The highest magnetic powers are developed in iron by the action of galvanic electricity. The magnet, again, is made to give galvanic shocks in a common form of battery, with the usual manifestations of light and heat. Chemical force develops light, heat, and electricity; and each of these is used constantly in the laboratory as a practical means of inducing chemical action. Heat alone is shown, by an experiment of Mr. Grove, to be capable of decomposing water. Further than this, as all forms of motion are capable of developing heat, or light, or electricity, according to the conditions under which it occurs, and as heat and electricity and chemical changes are habitually used to produce motion, it is questioned whether all the apparent varieties of force are not mutually convertible, there being in reality but one kind of force, which manifests itself in each of the different modes just spoken of according to the material substratum through which it is passing, or some other modifying cause. And as there are facts indicating the existence of a system of equivalents as prevailing in these conversions, or of a fixed ratio between the various convertible forms of force, so that a given electrical force will produce just so much heat or chemical decomposition, and either of these reproduce the original amount of electricity, it has been maintained that the total force of the inorganic universe is undergoing perpetual transfer, but never changes in amount, any more than the matter of the universe is altered in quantity by change of form.

This would be the noblest of generalizations, could we accept it without limit, as an established truth: — a few simple elements; the material world formed by their innumerable combinations; — one force, an effluence from the central power of creation, animating all; binding atoms, guiding systems, illuminating, warming, renewing, dissolving, as it passes through the various media of which the unbreathing universe is made up.

We may carry the generalization a step further. We know nothing of matter itself except as a collection of localized forces, points of attraction and repulsion, as Boscovich expressed his notion of its elements. Take a quartz crystal as an example. It resists the passage of certain other forces through a limited portion of space. It resists the separation of that sphere of resistance into two or more parts, by means of what we call cohesion. If a ray of light attempts to pass the portion of space within which these circumscribed forces have been found to act, it is thrown back or bent from its course. Here, then, are localized forces, or agencies that produce change; the existence of anything behind them — substance, or substratum — is a mere hypothesis. But while the fluent forces of the universe have been shown to pass more or less completely into one another, these collections of stationary forces which we call matter have hitherto maintained their ground against every attempt to reduce them to unity, or to render them in any degree mutually convertible. Our threescore groups of fixed forces, known as simple substances, defy all further analysis, so far as our present power and knowledge extend.

But we must remember that, even if the hypothesis of the absolute unity of the various imponderable agencies were established as a fact, we should still have to look somewhere between their sources and our organs for the difference in their manifestations. And this could be only in the media through which they act. If electricity becomes magnetic attraction in passing through iron, and iron only, we must look to the metal for the cause of its change of form. Thus we only transfer the differentiating agency from one sphere to another, in consequence of the experimental inferences of the

physicist and the chemist. If chemistry had reduced matter to some one mother-element, we should have been forced to refer all its different manifestations, such as gold, sulphur, oxygen, and the rest, to the influence of external agencies operating through them. The tendency of modern research, without claiming for its inferences the character of demonstration, is in the other direction; — unity of the fluent forces; diversity of the fixed forces, or matter.

Such are the data derived from the inorganic world with which we approach the consideration of the phenomena that belong to organized beings. According to their analogies we should look for the cause of any peculiar manifestation we might meet with, in the fixed forces or material structure of the organism.

When we commence the examination of this material structure, we find it so different from everything that we have met with in lifeless matter, that we are tempted to believe it must differ no less in elementary composition. The substance of these five hundred mute slaves that we call muscles, and the currents of this "running flesh" that we call blood, seem unlike anything in earth, air, or waters. But Chemistry meets us with her all-searching analysis, and tells us that this solid and this fluid, and all the other structures of the body, however varied in aspect, are but combinations of a few elements which we know well in the laboratories of Nature and Art. A few gallons of water, a few pounds of carbon and of lime, some cubic feet of air, an ounce or two of phosphorus, a few drams of iron, a dash of common salt, a pinch of sulphur, a grain or more of each of several hardly essential ingredients, and we have Man, according to Berzelius and Liebig. We have literally "weighed Hannibal," or his modern representative, and are ready to answer Juvenal's question. The wisest brain, the fairest face, and the strongest arm before or since Ulysses and Helen and Agamemnon, were, or are, made up of these same elements, not twenty in number, and scarcely a third of the simple substances known to the chemist. The test-tube, and the crucible, and the balance that "cavils on the ninth part of a hair," have settled that question. Appearances, therefore, have proved deceptive with regard to the composition of the organism.

Again, if we looked for the first time at the mode of action of the living structure, we should probably decide that the forces at work to produce the operations we observe must be of an essentially different nature from those which we see manifested in brute matter. Here are solids sustained and fluids lifted against the force of gravity. Here is heat generated without fire. Here is bread turned into flesh. Here is a glairy and oily fluid shut up in a tight casket, sealed by Nature as carefully as the last will and testament of an heirless monarch; and lo! what the casket holds is juggled into blood, bone, marrow, flesh, feathers, by the aid of a little heat, which, increased a few degrees, might give us an omelet instead of a chicken. Surely, we should say, here must be new forces, unknown to the common forms of matter. Yet appearances may deceive us, as they deceived us respecting the substance of the organism until the chemist set us right.

We must try the actions just as he has tried the elements. We are not bound to do for them any more than he has done for the materials he has worked upon. If he has stopped at analysis, and confessed that synthesis was beyond his powers, so may we. He has shown us the carbon, the iron, and the other elements of which blood and muscular fibre are made up. But he has never made a drop of blood or a fibre of muscle. We have done as much for physiological analysis, if we can show that such or such a living action is produced by some form of natural force with which we are acquainted as it appears in inorganic matter, although we cannot reproduce the living action by artificial contrivances. It is not to be supposed that the laboratory can present combining elements to one another under all the conditions furnished by the organism, nor that any one living act should be imitated after the mutually interdependent round of movements has been permanently interrupted.

Proceeding, then, to our analysis of the living actions, a very superficial examination shows us that many of the physical agencies are manifested in the organism in the same way as in ordinary matter. Thus gravity is always at work to drag us down to the earth. It holds us spread out on the nurse's lap in infancy. We stand up against it for some

three or four score years. Then it pulls us slowly downward again. The biped is forced to become a triped. The jaw falls by its own weight, and must continually be lifted again; so that old men, as Haller remarked, seem to be constantly chewing. It stretches us out at last, and flattens the earth over our bones, and so has done with us. Our fluids obey it during our whole lives. The veins of the legs dilate in tall men who stand much; the hands blanch if we hold them up; the face reddens if we stoop. The same cohesion that gives strength to knife-handles and tenacity to bowstrings serves the purposes of life in bones and sinews. The valves of the heart and vessels, which pointed Harvey to the discovery of the circulation, proclaim the obedience of the fluids to the laws of hydraulics. The tear-passages are filled by the force of capillary attraction. The skin soaks up fluids and allows them to escape through it, as membranes and films of paper and sheets of unglazed porcelain do in our experiments. The chemical reactions between the blood and the atmosphere, and between the gastric juice and the food, may be imitated very successfully out of the body. The eye and the ear recognize the ordinary laws of light and sound in all their arrangements. Levers, pulleys, and even the wheel and axle, play their usual part in the passive transfer of the forces that move the living machinery.

These facts, and many others of similar character which might be mentioned, point to the following conclusion. If there is a special force acting in the living organism, it must exist in addition to the general forces of nature, and not as a substitute for them. To know whether such a special force is necessary, or whether the general forces of nature are sufficient, we must know what these last are capable of doing, and what they cannot do, and must compare their ascertained power and its limitations with the living task to be performed. This is the next point to be examined.

That form of force which we call chemical affinity is capable of giving an indefinite number of aspects and qualities to matter, by varying the proportions and mode of combination of a few simple elements. Oxygen and nitrogen, which are the breath of our nostrils, become a corrosive fluid when

united in certain simple proportions differing from those of atmospheric air. The same elements, in varied combinations, serve us as food, or form a fluid, one drop of which kills almost like a stroke of lightning. Thus there is nothing exceptional in the fact, that the compounds of the vegetable or animal structure should present the distinctive characters by which we know them as starch or fat, as fibre or muscle.

Neither does there appear to be anything in the mere fact of assimilation, which establishes a distinct line of demarcation between the living and the lifeless world. A crystal, from a solution containing several salts, appropriates just the materials adapted to build up its own substance. A lichen does nothing more. The air is a solution of the elements that form it, and it appropriates and fixes them. The penetration of the new materials into the organic structure, and their interstitial distribution among its parts, might seem to draw the line of distinction. But this is very limited in many plants, and depends on their mechanical arrangement, one division growing upon the outside and another upon the inside. The porosity of organized beings which favors this mode of nutrition is nothing but an increase of internal surface; soluble nutritive matters are diffused through their textures just as water and other fluids pass into the pores of the Spanish *alcarraza;* and there is no reason why this internal surface should not appropriate new matter, as well as the external surface of a mineral.

The constancy of specific form is not more absolute in organized beings than in crystals. The difference between different crystalline shapes of the same mineral is not greater than that of the grub and the butterfly, or of the floating and the fixed Medusa.

Nor is a certain limitation of size a distinguishing mark of vitality. Some crystals are microscopic; some needle-like; some columnar. No diamond was ever found too heavy for a lady's coronet; but there are beryls which it would break a man's back to carry.

The plant and the animal have been thought to be peculiar in maintaining their integrity by continual waste and renewal. They are a perpetual "whirlpool," into which new

matter is constantly passing, and from which the materials that have been used are always being thrown out. It might at first seem hard to match this condition by any fact from the inorganic world. But from time immemorial, life has been compared to a flame, a spark, a torch, a candle.

"Et, quasi cursores, vitaï lampada tradunt."

The inverted flambeau of the ancients is still a frequent symbol in our rural cemeteries. Macbeth, Othello, John of Gaunt, have made the image familiar to us in different forms.

"My oil-dried lamp, and time-bewasted light,
Shall be extinct with age and endless night."

The simile is in fact a little fatigued with long use, and the Humane Society is hardly true to its name when it tolerates the expression that "the vital spark was extinct." But this is the very object of comparison that we here want, not for ornament but use. Professor Draper has beautifully drawn the parallel between the flame and the plant. The flame is not living, yet it grows; it is fed by incessant waste and supply; and it dies at length, exhausted, clogged, or suddenly quenched. The plant must suck up fluid by its wick-like roots, as well as the lamp by its root-like wick. The leaves must let it evaporate, as does the alcohol in an unprotected spirit-lamp. Here, then, is the mechanism of perpetual interstitial change, which we have a right to say may be purely physical in the one case, as in the other.

We need not wonder, in view of this perpetual change of material, that the living body, as a whole, resists decomposition. The striking picture drawn by Cuvier in his Introduction to the Comparative Anatomy, in which the living loveliness of youthful beauty is contrasted with the fearful changes which a few hours will make in the lifeless form, loses its apparent significance when we remember the necessary consequence of the arrest of its interior movements. The living body is like a city kept sweet by drains running under ground to every house, into which the water that supplies the wants of each household is constantly sweeping its refuse matters. The dead body is the same city, with its drains choked and its aqueducts dry. The individual system, like the mass of

collective life that constitutes a people, is continually undergoing interstitial decomposition. If we take in a ton every twelvemonth, in the shape of food, drink, and air, and get rid of only a quarter of it unchanged into our own substance, we die ten times a year; not all of us at any one time, but a portion of us at every moment. It is a curious consequence of this, we may remark, by the way, that, if the refuse of any of our great cities were properly economized, its population would eat itself over and over again in the course of every generation. We consume nothing. Our food is like those everlasting pills that old pharmacopœias tell of, heirlooms for the *dura ilia* of successive generations. But we change what we receive, first into our own substance, then into waste matter, and we have no evidence that any single portion of the body resists decomposition longer during life than after death. Only, all that decays is at once removed while the living state continues.

As for our inability, already referred to, to imitate most of the organic compounds, it is no more remarkable than our inability to manufacture precious stones. Some combinations take place readily; others require the most delicately adjusted conditions. Potassium and oxygen rush into each other's arms, like true lovers. Iron blushes a tardier consent before changing its maiden name for oxide. The "noble metals" are coy to the great elemental wooer; they must be tampered with by go-betweens before they will yield. Chlorine and hydrogen unite with a violent explosion, if exposed to sunlight. Hydrogen and oxygen resist the mediation of the sunbeams, but come together with sudden vehemence if crossed by the electric spark or touched by a flame. Most bodies must be dissolved before they will form alliances; "corpora non agunt nisi soluta." Some can combine only in the nascent state; like princes, they must be betrothed in their cradles. There is nothing strange, then, in the fact, that combinations formed in the vegetable or animal laboratory should be hard to imitate out of the body. Yet the chemist has already succeeded in forming urea; and artificial digestive fluids, borrowing nothing from life but a bit of dried and salted rennet, do their work quite as well as the gastric juice

of many dyspeptic professors. These instances show us that, if we can only supply the necessary conditions, the chemical forces are always ready. Nature expects every particle of carbon, and the rest, to do its duty under all circumstances. The digestive secretions often devour the stomach after death. A drowned man is restored by artificial respiration; the air forced into the lungs changes the blood in their capillary vessels; the blood thus changed is enabled to flow more freely; the heart is unloaded of its stagnant contents, and roused to action; the round of vital acts is once more set in motion; and all this because carbon and oxygen are always true to each other.

We are obliged to confess, as the result of this examination, that the inherent and inalienable relations of the elements found in the living organism may be sufficient to account for all the acts of composition and decomposition observed during life, without invoking that special "chimie vivante" which Broussais and others have supposed to be one of the properties of organization.

There is another mode of operation found in animals and vegetables, which has been considered as depending upon special *vital*, in distinction from physical, causes. This is the process by which certain bodies are selected from others for absorption or secretion; as when the chyle is taken up by the lacteals, and the bile is separated from the blood by the liver. To account for this, the organs have been supposed to possess a certain "low intelligence," which directs them in this selection. Yet there is evidence that the ordinary physical laws are not idle in these operations, and it is fair to ask if they may not be the only real agencies. The lacteals will not take up oily matters until they have been turned into an emulsion by the pancreatic fluid; just as a wick wetted with water will not take up oil until this is emulsified, or made a soap of.

We may still inquire why each secreting gland forms or transmits its own special product, and no other; why the liver secretes only bile, and the lachrymal gland only tears. We can see nothing in the anatomical formation of these organs to account for their peculiar modes of action. But

there are many phenomena of simple physical transudation equally unexplained. When water and alcohol are separated by a membrane, a current is established between the fluids in both directions, that from the water to the alcohol — the denser to the lighter — being the most rapid. When a similar experiment is performed with sirup and water, the current is from the water to the sirup, — the lighter to the denser. When the same fluids are employed, the nature and position of the membrane used occasion differences which we cannot explain. With the skin of a frog, the current from the water is most rapid when the internal surface is towards the alcohol. But with an eel-skin, the reversed position is most favorable to the flow in the same direction.

Again, in the phenomena of precipitation, as seen in the laboratory, we have an illustration of the chemical side of secretion. Two clear fluids are mixed, and one of them immediately separates or secretes one or more of its elements as a distinct product; or both may be decomposed with entire transformation of aspect and properties. Or a simple solid substance is introduced into a fluid compound, and at once seizes upon some constituent, and appropriates it, as when iron is immersed in solutions of salts of copper. Still more striking is the well-known action of spongy platinum in producing the combination of hydrogen and oxygen, without undergoing any chemical change itself.

Let us see whether some of these same physical operations may not be manifested in the liver, taking this as the typical secreting organ. Its cell-walls may govern their currents of transudation by laws of their own, as eel-skins and frog-skins govern the currents of alcohol and water. The two kinds of blood that meet in its capillary vessels may react upon each other, and produce mutual decomposition, as well as any other compound fluids. The substance of the liver has as much right to appropriate fat, without a special license from vitality, as the iron, in the experiment referred to above, to appropriate copper. It may have as good a title from the Supreme Authority to join the elements that form cholesterine, as spongy platinum to unite hydrogen and oxygen. This catalytic agency — the priestly office of chemical nature that gives to

one body the power of marrying innumerable pairs of loving atoms, itself standing apart in elemental celibacy — is not to be denied its possible place in the living mechanism. Its action may, perhaps, be more extended than in inanimate bodies. The instances furnished by the action of the pancreatic fluid and the gastric juice may belong to a far more numerous series of similar phenomena. We may grant a difference of degree between the separations or secretions effected by the reactions between the complex elements of the organism, and those witnessed in unorganized matter; but the difference of essential nature is less easily demonstrated.

But it will be said that the several parts select their special secretions with reference to the general wants of the system. If there is no evidence of adaptation of parts to a whole anywhere except in living beings, then we must allow that here is a difference in kind as well as in degree, which it would be hard to reconcile with the supposition that the same forces are the sole agents in both cases. But it is vain to deny that the macrocosm shows the same adaptation of parts as the microcosm. When the Resolute was found adrift and boarded by the American sailors, there was no sail on her masts, and no hand at her helm. Yet there was just as much evidence in her build and equipments that she was framed and provided for a definite purpose, as if the good ship had been seen with all her men at the ropes and the steersman at the wheel, following a lead into the ice-fields of the North. So if the earth had been visited by some wandering spirit before a fern had spread its leaves, or a trilobite had clashed his scales, the evidence of adaptation of its several parts to one another, as well as to ulterior ends, would have been clear as the sun that shone upon its primeval strata. Its steady circuit through the heavens, exposing it on all sides to light and shade in succession; the qualities of matter that lead its various forms to arrange themselves as shapeless matrix, or geometrical solid, into ever downward-sinking waters and ever upward-rising atmospheres; the self-preserving and self-classifying tendency, constantly at work to educe new harmonies out of the destroying conflict of the active powers of nature, — show that the adaptation of parts to the whole is wider than the realm and older than the reign of life.

All the physical laws, in and out of the organism, are arranged in harmony with one another. Each organ of a plant or an animal is supported by, and accountable to, the general system. But this system holds the same relations to the surrounding universe. Every creature that is born has an account opened at once with Nature, — debtor by so much of carbon, oxygen, hydrogen, azote; creditor by so much carbonic acid and ammonia, or whatever may be the medium of payment. Life is adapted to maintain a certain normal composition of the atmosphere, as much as the atmosphere to maintain life. And as air existed before plant or animal lived to breathe it, and as air is made up of at least three elements, each of these, considered as a part, was adjusted in quality and quantity to the whole with the same fitness that we see in the relation of the amount and quality of the bile as compared with the other secretions and the wants of the system.

But the living system protects itself by special provisions, it will be said; look at the thickened cuticle upon the workingman's hand, and see how admirably it shields the sensitive surface. True; and see also how delightfully the same thickened cuticle acts in the case of a *corn*. The avidity with which the most deadly substances are sucked in by the skin, — the suddenness with which a single drop of poison will work its way through the system from the surface of a mucous membrane, — shows us that the same force acts for good or bad indifferently; that is, it is under the general law of harmony, but not modified to meet accidental conditions. Just so, in the greater universe, the tide rises by one of its beneficent provisions, wafting a hundred fleets into their harbors, but not less surely drowning the poor wretches who are caught on the sands by its advancing waters. "Faugh a ballagh!" — "Clear the coast!" — is the word when we get across the track of any natural agency. We must not expect it to turn out for any particular end; the Creator has imparted no such wisdom to matter.

The course of a single ray of light is the eternal illustration of the Divine mode of action. It is always in straight lines. The difference between our utilitarian methods, always looking to special ends, and the Supreme handling of things

in their universal aspect, is beautifully shown in the structure of one of our domestic animals. If a watchmaker should insist on putting into a common watch one little wheel, unseen, and unconnected with the rest of the machinery, because he had made repeaters which required such a wheel, we should smile at his lost labor. But there is a little collar-bone, too small to be of any use, floating in the midst of the muscles about a cat's shoulder, which is as constant as if the animal's welfare depended on it. Why is it there? It is the vanishing point of a series of models formed on one general plan. The plan, as a whole, is a monument of infinite wisdom, adapted to the various needs of a numerous series of conscious beings. But it is so vast that it includes what we call *utility* as one of its accidents, and this anatomical fact shows us one of the borders at which the Divine conception overlaps the temporary application. The human artisan is wise in leaving out the wheel when it is no longer wanted. But the seemingly trivial arrangement just mentioned shows that the Deity respects a normal type more than a practical fact. His thoughts and his ways are not as ours.

The limited duration of existence might be thought to be characteristic of organic being. But, in the first place, this fact is not so universal and absolute as might be supposed. De Candolle long since promulgated the doctrine that trees live indefinitely, and never die but from injury or disease. The death of our great forest-trees is commonly owing to fracture, in consequence of the decay of the inner portion of the stem, which no longer performs any but a mechanical office. On the other hand, many crystals undergo decomposition, of form at least, within a longer or shorter period, by efflorescence or deliquescence. The very conditions of organic life imply a liability to disable its implements. A river chokes up its own bed with detritus; a chimney fills itself up with soot. The organism is a multilocular sac of fluids that are loaded with dissolved and suspended matters. The smoke of life ascends from innumerable pores of animal bodies, from the first gasp to the last breath that is expelled. What marvel that the vessels become thickened, and the working organs clogged, with accumulating deposits? We can only wonder, with the

hymn to which we have referred, that the harmony of so exquisitely adjusted a mechanism should be so long maintained, and not at all at the brevity of life in any of its forms, or the diversity of its duration.

But there is the great mystery of reproduction. Are there any acts of inorganic nature parallel to those that take place in the development of an embryo of one of the higher animals? This development may be decomposed into the following separate elements: — 1. A movement of assimilation imparted by an organism to a separable product of secretion or of growth; 2. A differentiating movement, which divides and arranges the formative materials into the substance of tissues and organs; 3. A modelling force, or shaping agency, which determines the form of the several parts and of the whole; 4. A co-ordinating force, which brings the various separate acts into harmony with one another, the *motus regius* of Lord Bacon.

Now, the question is, not whether all these actions are combined in any other known group of material changes than embryonic development, but whether any one of them is absolutely *sui generis*. And, first, we do not see why molecular movements may not be imparted by one portion of matter to another, as well as movements in mass. Fire is so propagated, and forms a new centre independent of its origin. Magnetism is imparted from one body to another, without diminution of its intensity in the first. Secondly, the rending apart of the most intimately combined elements, and their distribution to the positive and negative poles respectively, may illustrate the separation of the several constituents of the embryonic structure from one another. A very weak current will decompose saline mixtures, and even refractory oxides. Heat alone, as we have seen, will decompose water. Is it not in harmony with these physical facts, that a weak current of heat, long continued, as in incubation, should induce the separation and *quasi* polar arrangement of the loosely combined atoms that are to form the embryo? Thirdly, is not the shaping power more obvious in the rhombs of a fragment of Iceland spar than in the disc of a lichen, which falls on a stone, and spreads just as a drop of rain would spread? We may,

in fact, see the two forms of the modelling process — Nature's plane and spherical geometry — in operation side by side in the same structure. The *raphides*, or included crystals, which we often find in great abundance in vegetable cells, — those of the onion, for instance, — illustrate the point in question. Lastly, we have already seen cause to deny that the principle of harmony of parts, or multiplicity in unity, can be confined to living bodies, without overlooking the most obvious adjustments of the elements of general nature to one another and to one great plan. "The wonderful uniformity in the planetary system," says Newton, "must be allowed the effect of choice; and so must the uniformity in the bodies of animals."

It appears from the survey we have taken, that we might expect, from the general character of the creative plan, that, as pre-existing materials were employed to form organic structures, so pre-existing force or forces would be employed to maintain organic actions, or unconscious life. It is certain that the materials of the organism are, to a great extent, subject to the common laws of mechanical and chemical forces. It is not proved that these same forces are incompetent to produce the whole series of interstitial changes in which the functions of life common to vegetables and animals consist. On the contrary, the more we vary our experiments and extend our observation, the more difficult we find the task of assigning limits to their power. The preservation of specific form and dimensions has not appeared to be confined to living beings. The co-operation of the parts of an organized structure does, indeed, imply a plan, or pre-established harmony, but no more than the arrangement of the spheres, or the relations of the elements to one another. Each little world of life shows only the same *solidarity*, on a small scale, that prevents the universe from being a chaos. Limits of duration are not peculiar to living beings, nor always evident in them. Reproduction combines several modes of action, no one of which is without its inorganic parallel.

Given, then, a plant or a man, there seems no good reason why either should not begin to live with all its might, so soon as the conditions of light, heat, air, — whatever stimuli or food it requires, — shall be made to act upon it. Such is the

case with the drowned man who is "brought to life." He was defunct to all intents and purposes, except that the organs and fluids had not had time to become clogged, or decomposed, when a whiff of air set the whole machinery going again. "Two is my number," said Sir Charles Napier. "Two wives, two daughters, two sons, and *two deaths*. I died at Corunna, and now the grim old villain approaches again." Life is not the absolute unit we suppose. If a man is dead who "breathes his last," or "expires," such dead men have unquestionably been restored to life without a miracle. In other words, a man may be dead conditionally, — dead, unless there happen to be a double bellows or a galvanic battery in the neighborhood, and some one who knows how to use it. But if a man is not dead so long as any so-called living process goes on, then most men are buried alive; for there is no doubt that certain secretions — the mucous secretion, among others, as one of our best pathologists thinks — take place for a considerable time after a person has "expired." Probably a certain number of those who have just died or expired could be resuscitated to movement, if not to consciousness, by artificial respiration, if it were a thing to be desired. The reason that they cannot be permanently restored, like those rescued from the water, is that some organ or fluid has undergone an important injury, in the vast majority of cases, if not in all.

Life is a necessary attribute, then, of a perfect organism exposed to the proper external influences, just as much as gravity belongs to a metal, or hardness to a diamond. Just as the Creator, in calling the material elements into existence, contemplated their fitness to form a part of the living creation yet to be, so did he also diffuse such forces, or forms of force, through the world, as should of necessity manifest themselves through any perfect organism as what we call life. Such is the conclusion pointed at by the range of analogies we have adduced. A vast number of facts testify in its favor, and it is hard to find any that oppose it which cannot be explained. Whatever incomprehensible mystery there may have been in the first fabrication of these living time-keepers that measure ages in their conscious or unconscious movements, one com-

mon key seems enough to wind them all up and set them going. We may not accept Mr. Newport's generalization as to light, but whatever form of force we may recognize as the *primum mobile* in the series of organic movements, we are contented to accept as the chosen mode of action of the all-pervading Presence. If the Deity has seen fit to make one agent serve many purposes, the fact will be acquiesced in, in the face of the threatened San Benitos of all the Linnæan Societies.

The battle-ground of Atheism is not in the field of natural science; meaning by that the study of material phenomena. The argument from design to an intelligent Contriver does not require the knowledge of Cuvier or Humboldt to make it satisfactory. Every man carries about with him in his own organization a syllogism which all the logic in the world can never mend. If his scepticism will not melt away in such an ocean of evidence, it is because it is insoluble. Whatever contrivances have been employed, the grand result of an immeasurable whole, all the parts of which are fitted together with a foresight and wisdom which it mocks the human intellect to attempt to sound, except along its shallower edges, remains to be accounted for, and Paley's argument from the watch to its maker illustrates the simple course of reasoning which the healthy mind is naturally forced to follow.

The evidence we have been considering applies to the perfect and mature organism, and does not reach the question how such organisms first came into being. Who shall tell us whether the first egg was parent or offspring of the first fowl? The poet must answer for the philosopher. Milton has ventured to paraphrase the Scriptural account of creation with a freedom not always allowed to modern science. "The tepid caves, and fens, and shores" hatch their feathered broods from eggs. The grassy clods become the mothers of young cattle. The bees appear, not a single pair, but "swarming," as our own naturalists tell us they must have appeared. But our prosaic evidence as to the introduction of the forms of life upon our planet is limited.

And, first, there is no authentic evidence that the development of any organism has been directly observed without the

demonstrated or probable presence of a germ derived from a previous structure having similar characters. Even the vexed question of the origin of the entozoa, or internal parasites, has received its approximate solution from modern investigations. The tape-worm, for instance, is found to exist in two different forms, or stages of development. Each perfect tape-worm contains some twelve millions of eggs, capable of being reduced to a floating dust, and thus being deposited on various articles used as food. The mouse, nibbling at everything, swallows some of these, and they grow in his body into the state of *cystic worms*, an intermediate form of development, only of late recognized as being a stage of the tape-worm's growth. By and by the cat eats the mouse, and the cystic worm, finding its proper habitat in this animal's alimentary canal, assumes the true proportions of the *tænia crassicolis*. And so another cystic worm, which is common in the flesh of oxen, sheep, and especially pigs, becomes, by a similar metamorphosis, the *tænia solium*, or long tape-worm of their human consumer. The tribes that live on raw flesh are said to be particularly subject to the tape-worm. The hint derived from their experience may serve as an offset against Dr. Kane's Arctic experience, and the recommendation of a raw diet from nearer sources. So far as our immediate object is concerned, we have got rid of one enigma in finding, not only the cradles, but the nurseries, of these entozoa. We are obliged to consign the supposed instances of equivocal generation derived from their history to the same category with Virgil's swarm of bees born from a decaying carcass.

But, in the second place, the evidence of Geology has made it plain that new forms of life have been called into being at many different periods of the earth's history. The multitude of distinct floras and faunas in different regions and strata of the earth sufficiently proves that the formation of new organisms has been as much a part of the regular order of things in creation as the precession of the equinoxes, or upheavals and depressions, or any of those changes that work out their great results in the longer cycles of time. No one who observes the manner in which new specific forms are gradually introduced among those already existing, can help

seeing that such new formations may have been quietly intercalated in the midst of their predecessors by a series of operations in which, as in the mighty processes by which new continents are uplifted, nothing but secondary agencies were apparent. Chemistry teaches us, as we have seen, that no new materials were required to be called into being. It is not to be supposed that certain parcels of carbon or of oxygen were created when the first living forms, containing these elements as a matter of necessity, were fashioned, inasmuch as they already existed in immeasurable abundance. What was wanted was not the materials of the organism, or of its germ, but the force to bring them together without the intermediate action of a parent structure. The creation of matter out of nothing is perfectly credible as a fact, but not definitely conceivable by our imaginations. The combination of pre-existing elements, and the development of new properties in the resulting compound, is what we daily witness.

If the most insignificant infusorial plant or animal, having well-defined specific characters, had been evolved under our own eyes, in circumstances precluding the possible existence of a germ derived from a previous similar being, the fact would furnish us with a theory of the organic creation, so far as the purely vital, not the spiritual, side is concerned. Not having any such fact to appeal to, but, on the contrary, finding the rule that whatever lives comes from a germ absolutely universal, so far as we are acquainted with actual life, we are reduced to barren speculation as to the special mechanism employed in the many changes of programme which the palæontologist points out to us in the vegetable and animal world of the past.

"The world is in its dotage, and yet the cosmogony, or creation of the world" puzzles us, as it did the philosopher from whom these words are cited. By feeling our way up, through what is possible, or at least conceivable, from the laws of the inorganic world to the simplest manifestations of life, we may construct a theory of the evolution of life by means of the existing forces of nature, acting in different degree or intensity from their present ordinary mode of operation.

Let us construct such a theory, not to lean upon it, but to

see what degree of plausibility it may present, or how its weakness may drive us to another hypothesis. We will try to make the most of it, as an advocate pleads his client's cause without compromising his private opinion. Suppose the problem to be the mechanism of the introduction of vegetable life. And, first, let us illustrate our possible relations to this question by an imaginary picture of a body of philosophers of a somewhat ruder stamp than ourselves, and the statement of a question which may have occurred to them, and taxed their highest faculties.

A group of savages, living in a remote island, have from time immemorial been in the habit of employing fire for warming themselves and in cooking. They never suffer it to be extinguished everywhere at once, for they know that they cannot rekindle it except from another fire. They breed it as we breed trees in our nurseries. The fact of burning is no more a mystery to them than any other natural fact; its phenomena are constant, determinable beforehand, and controllable, and although they cannot talk about carbon and oxygen as button-using sages talk, they practically know the laws of combustion. They know that fire is prolific and self-developing; that it has its little red seeds, and in due time its slender buds, and broad waving corolla, like a flower; that it loves air, and hates water; that it gives pleasure or pain, according to the way of using it; that it renders the flesh of the canine race still more acceptable than their living presence, and even adds new tenderness to the paternal relation, in case of premature bereavement. All this they know. But if they are asked where the first fire came from, or how it was born, they have no answer to render, or only an idle story to tell. It was the gift of the Great Spirit, or some tawny Prometheus stole it from heaven. As for any mechanism by which it can be produced, they are entirely unable to suggest or conceive it. The wind, they know, fans a spark into a flame, but they laugh at the idea that the wind should kindle a fire without a single spark to begin with. At length a great hurricane sweeps over their island. It sways the tangled forest-branches backward and forward; it rends and twists and grinds them, until the earth is strewed with their fragments.

Two dry boughs are swinging across each other, and chafing in the blast. Presently a smoke rises from their point of crossing, and then a flame, — the woods are set on fire; but the great mystery is solved, and from that time forward the natives rub two sticks together when they desire to have the means of warming their fingers, or discussing the merits of such game as they may have bagged in their last skirmish.

We stand in the same relation to the origin of vegetable life as that in which the savages stood to the origin of fire, before the tempest revealed it. Give us but one little vegetable spark, and we can in due time kindle it by our appliances into a flame of blossoms wreathed in a cloud of foliage. Thrust into the soil this little brown scale, one of those which the elm has dropped in thousands at our feet, and it will go on towering and spreading until it overshadows the fourth part of an acre. Take this double-winged germ, that looks so like an Egyptian amulet, and bury it. Out of its core will spring a tall shaft that will wear its greenness for a century, though scarred with many a wound, through which its sweet juices have been stolen. This persistent force, building up the elm and the maple out of such mere specks of matter, holding steadily to the specific characters of each in every diversity of soil and climate, and maintaining them through the vicissitudes of a hundred seasons, is as great a mystery as would be the production of such a seed as either of those mentioned by deposition from the air which contains their elements, or their formation *de novo* from any collection of their proximate principles. It is only because we are not in the habit of witnessing the formation of germs as a daily occurrence, that we invest it with preternatural conditions. Geologists, who are constantly dealing with successive new creations, learn to accept the primitive evolution of an organism as a regular process, equally with its continuance. The lighting of a friction-match is not more wonderful, than the conflagration of a great city which it kindles. If Schultze and Schwann had succeeded, instead of failed, in their experiments on equivocal generation, we should have taken the fact as quietly as the invention of lucifers.

Let us proceed with our theoretical construction. We

have as much right to say that carbon has a tendency to take the form of a plant under certain circumstances, as that it has to become a diamond under other conditions. We do not see it changing directly into a plant; did we ever see it crystallizing into a diamond? Let us now consider the earth just at the period before the first evolution of vegetable life. As uncounted billions of tons of carbon have since been abstracted from the atmosphere to represent what we may call the fixed organic capital of our planet, as well as vast quantities of other elements derived from the earth and the waters, we may suppose the soil and atmosphere to have then represented a saturated solution of the elements of vegetable organisms. Some change of condition, natural, but exceptional, like the hurricane in our imaginary picture, — an influx of alien elements from some distant source, or an alteration of temperature, for instance, — destroys the equilibrium of the solution. There takes place a vast precipitate of living crystals, — needle-like, acuminated, porous, crusted with an inorganic coat of silex, — the grass that covers the plains and hill-sides. The organic solution having been thus reduced, the next living precipitate may probably be of a different grade, more slowly formed, more complex, a higher vegetable growth. Would this process be a whit more incomprehensible than the deposition of a cube of common salt from a clear fluid? Now, although a nucleus in the shape of a pre-existing cube of salt helps and accelerates this last process, it is not always necessary to it. So the living shape, which commonly depends for development on its pre-existing nucleus, or germ, may be conceived, under certain conditions, to be formed without it, obeying the same general forces, which are confessedly strong enough to shape and build up a mighty tree out of a mere particle of matter, or more properly from the elements, to which this particle has given their first direction. After a certain number of vital precipitations, we might suppose the solution, atmospheric or other, of the organizable substances, to retain just so much of these principles as would be sufficient to keep up the integrity of the organic deposits. The cube of salt will retain its form indefinitely, if kept in the fluid from which it was deposited. And thus we see a reason for the fact that

every organism is immersed in a solution of its own constituents. It does not follow that we must be able to imitate this natural process by our artificial arrangements. To say nothing of our very imperfect control of the natural forces, the scale of magnitude of the experiment may entirely determine the results. Spontaneous combustion happens not unfrequently in heaps of vegetable matter; but no experimenter will expect the same substances to take fire in such quantities as he examines by the microscope.

It is only going a step further in our supposition to conceive the first stage of vital precipitation as a simpler process. We may suppose the living precipitate to consist of what we may call *indifferent germs*, that is, assimilating and self-developing centres, determinable, but not yet determined; bearing the same relation to vegetable growths generally, which the seed of an apple or pear bears to the many possible varieties that may spring from it. This hypothesis is by no means identical with that of progressive development. It supposes the existence of permanent types, but conceives each type to represent the plastic diagonal of two forces, — a general organizing principle and a local determining one. The line of direction once fixed persists indefinitely, self-perpetuating, in the individual and the species, a vital movement parallel to its own axis. It is not our fault if these indifferent germs are the same things as the *semina rerum* of the old heathen Lucretius and his masters; the question is, whether they do not assist our conception of the mechanism of creation, and remove a part of its seeming difficulty.

We might apply this hypothesis of indifferent germs to that singular parallelism without identity observed in the organisms of remote regions. The resemblance between many growths of the Eastern and Western continents, for instance, would follow as the result of the diffusion of identical germs amidst similar, but not identical, general conditions of soil and climate. The same series of resemblances might be expected, which we see in distant, but corresponding, parts of the body, in various affections of the skin. Both arms or both cheeks often present very nearly the same diseased aspect, the blood being the common source of the disturbing element,

and certain corresponding parts on the two sides of the body furnishing the conditions for its development. So the two planetary limbs thrust through the folds of the ocean, one on either side, may be supposed to throw out their grasses, or oaks, or elms; like each other, but not the same.

"God has been pleased," says Paley, "to prescribe limits to his own power, and to work his ends within these limits." We can conceive of the introduction of vegetable life without any over-stepping of the present self-prescribed limits of Divine power, as we understand them. It is not absurd to suppose that new vegetable types may be forming from time to time in the existing order of things. The vulgar belief is in favor of such occurrences. The extraordinary fact of the appearance of oaks after a pine-growth has been removed, and other occurrences of similar nature, have never been thoroughly investigated, so far as we can learn. Scientific men question curiously on the subject; there is a doubt in their minds about the acorns, if they accept the facts about the oaks, as commonly alleged. It is strange that such substantial seeds should be scattered so widely. It is stranger that such perishable matter as they hold should retain its vitality so long. The experiments on equivocal generation have been made too recently, and by men of too much judgment, to allow us to treat the doctrine with contempt. A thousand negative experiments can never settle the question definitively. We do not say that it is probable, but we cannot say it is not true, that new types may be intercalated every century or every year into the existing flora. If the Dix pear was created for the first time in a garden in Washington Street, who shall say that the same power may not have just given us a new fungus in some corner of its vast nursery?

Whatever difficulties we find in attempting to frame a conception of the first evolution of *animal* life, there are certain facts which we are authorized to take as guides in our reasonings or imaginings upon the matter. Science confirms the statement of Revelation, that animal life must have come into being after vegetable life. The plain reason is, that plants are necessary to prepare the food of animals. And since no existing animal organism is ever built up directly from the

elements, but only out of materials derived directly or mediately from the vegetable world, we may question whether those first created were put together directly from the elements. The first animals were necessarily placed where their food was abundant. But their food contained the elements of their bodies, and why should not the proximate principles contained in the accumulations of vegetable matter about their birthplace have furnished the materials of the first, as well as of all subsequent organisms?

The primordial development of the higher animals presents this peculiar difficulty, — that their germs depend for their evolution on their continued connection with the parent. We can conceive of an infusorial seed or ovum as being formed by the "concourse of atoms," guided by that Infinite Wisdom which we see every day grouping the same atoms about their living nuclei. Reasonable men experiment with the hope of observing such a fact. But no one since Paracelsus — unless it be the mother of Frankenstein — has thought of getting up an artificial *homunculus*, or *homo*, or even a lower mammal, or a bird. Vaucanson's duck was perhaps the nearest approach to such a performance. He could utter the monosyllable abhorred of medical men, and make himself disagreeable in more ways than it is necessary to mention. But he was nothing better than wood, and illustrates the hopeless distance between the best of our paltry toys and the universe of miracles shut up in any one of the more perfect animal organisms. So difficult has the problem of the evolution of the higher animal forms appeared to speculative philosophers, that they have invented the theory of progressive development of the superior from the lower types. The sharp lines which separate species, as shown by observation of every organic form, extinct as well as living, have caused this famous and seductive hypothesis to be very generally rejected as untenable.

With all the difficulties, however, that stand in the way of our conceiving of the evolution of a mammal by the aid of the general forces of nature acting on the organic elements, we do not see where to draw the line which shall separate the higher from the lower forms of life, and assign a different ori-

gin to the two divisions of the series. Reasoning from below upwards, we should come to this frank conclusion, that, as definite form, limited duration, growth and decay, harmony of parts, transmissible qualities, all implying a controlling intelligence, are manifested in the inorganic world, we cannot assume that the same forces which produce its phenomena may not show themselves through all forms of organized matter as *vital* force. And as the conditions of action of these forces must have varied at different periods of the earth's history, we cannot assume that they have always been incompetent to bring together the elements of organized matter. The various organic forms which we observe fossilized in the strata of the earth, without any parent structures in the subjacent layers, may be considered as marking by their appearance the epoch of successive "fits of easy transmission" of the plastic elemental influence.

> "Sed, quia finem aliquam pariundi debet habere,
> Destitit; ut mulier, spatio defessa vetusto."

And here we leave this aspect of the question, to look at it in another point of view.

We recognize two, and only two, great divisions in created things. To the first class of his creatures the Deity sustains only active relations. All their qualities, functions, adjustments, harmonies, are immediate expressions of his wisdom and power. Every specific form is a manifestation of the Supreme thought. Every elemental movement is the Sovereign's self in action. The only question is whether he has at one time been present in our elements with an organizing force, and afterwards withdrawn this particular manifestation, or whether under the same conditions these elements would always manifest his ideas in the production of the same forms, just as they now maintain the present forms of life by a perpetual miracle, which we fail to recognize as such only because it is familiar to our daily experience. We have stated, as well as our space permitted, the argument for the presence of an organizing force in the elements around us.

To the second class of his creatures the Creator stands in passive as well as active relations. They are no longer simple instruments to do his bidding. They may disobey him,

and violate the harmonies of the universe. They have the great prerogative of self-determination, which, with knowledge of the moral relations of their acts, constitutes them responsible beings.

Now, if our previous view of matter and of elemental force as continuous Divine manifestations is correct, they could not in the nature of things become self-determining existences. The creation of independent centres of will and action involves a change in the character of the formative agencies hitherto at work in the portion of the universe with which we are acquainted. And here we come at once upon that mystery of mysteries: How and when are these spiritual natures called into being, and what is their relation to the material frames whose fundamental vital action we have alone considered? Have they existed in some former state, as Plato taught in the Academy, and Dr. Edward Beecher has maintained in the Church? Are the shores of embryonic life crowded with souls waiting for their bodies, as Lucretius tells his readers was the foolish fable, and as Brigham Young reveals to his congregation and announces in his harem? Or can it be that Tennyson has solved the difficulty when he tells us that,

> "star and system rolling past,
> A soul shall draw from out the vast,
> And strike his being into bounds,
>
> "And, moved through life of lower phase,
> Result in man, be born and think"?

Or does the soul organize its own body, as thoughtful men have held, from Aristotle to Mr. Garth Wilkinson?

Into these and similar questions we cannot now enter, if under any circumstances we should be willing to cast a line into such fathomless abysses of speculation. But as we have followed the physical view of life upward until we have reached an impassable limit, it is but fair to indicate briefly the reversed aspect of living nature, when viewed from above downward, by taking, as the point of departure, its spiritual apex, instead of its material base.

The introduction of self-determining existence, or sub-creative centres, into the order of things, marks, as we have said, the great change of action by which Omnipotence saw fit to

assume passive, as well as active, relations to its creatures. There is nothing in light or heat, or electricity, or chemical or mechanical force, that can give any account of spiritual existence. When the first human soul was introduced to earthly being, if not before the date of this last birth of creation, there was a new force put forth which was not any of these. And so, whenever a new soul takes mortal shape, we recognize it as an emanation from its Maker by some other channel than through the elemental substances or influences that wait upon its secondary and simply organic necessities.

We could not think it strange that, at the period of this spiritual evolution, a force running parallel with it in the material world, — a force not identical with any of the ordinary physical agencies, — should combine the elements of the bodily form, and shape it to the wants of the immaterial principle. We should not therefore be constrained to throw upon the common forces of Nature that wonderful development from simple to complex, from general to special, which carries a translucent vesicle through a series of evolutions and differentiations, until it wears the shape of the august being to whom the Deity has delegated a portion of his omnipotence. But this conclusion would oblige us to argue backward from it to the lower animals, whose material frames and food-needing existence are essentially identical in their composition and mode of being with our own. And conceding that a special change of character in the forces of Nature marks the appearance of animal life, there would be strong reason for extending the same supposition to the vegetable kingdom. This is only one instance of the difference between our conclusions when we look from the higher sphere, and those which we naturally accept from the workshops of material philosophy. We must be content to remain in doubt on many details of creation not revealed to us, on which we can only shape a few half-shadowed hypotheses.

In conclusion, we recognize our spiritual natures as having only incidental and temporary relations with the material substance and general forces of the universe. But we may concede that, the farther our examination extends, the more completely the organic or simply vital forces appear to resolve

themselves into manifestations of those closely related or mutually convertible principles which give activity to the unconscious portion of the universe. We have no experimental evidence that these physical agencies can form any living germ by their action upon matter; nor can we prove the contrary. The only directly observed conditions of the evolution of a living structure involve the presence of a germ derived from a being of similar characters. But observation of the earth's strata shows that new forms of life have appeared at numerous successive periods by some other creative mechanism. We can frame hypotheses not inconsistent with the ordinary laws of matter to account for such formations, but they can be regarded only as more or less ingenious speculations. We are obliged to recognize a special intervention of creative power in the introduction of spiritual existence in the midst of the pre-existing unconscious creation. If we allow that higher modes of action have once been superinduced upon the ordinary physical forces, we cannot deny the possibility, and even probability, of repeated changes in the working machinery of creation, coinciding with the evolution of each new type of organization. And if new formulæ of force in combination with matter preceded the creation of each organism, or group of organisms, we can understand that a special *vital* formula may be involved in the continuance of their existence. Thus accepting the fact of a change of law as a possible part of the constitution of the universe, we arrive, independently of Revelation, at the doctrine of Miracles, as this term is commonly understood. But in the view we have taken, whatever part may be assigned to the physical forces in the production and phenomena of life, all being is not the less one perpetual miracle, in which the Infinite Creator, acting through what we often call secondary causes, is himself the moving principle of the universe he first framed and never ceases to sustain.